

# BLOCKING ACTION OVER THE NORTHEAST DURING THE LATTER HALF OF FEBRUARY 1951

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## INTRODUCTION

The development and effects of blocking action in broad-scale circulation patterns have been the subject of several recent investigations [1, 2, 3, 4]. Such "blocks" are frequent during the month of February, a period of the year that is favorable for the maintenance of warm anticyclones in northerly latitudes and cold cyclones in southerly latitudes [1]. This article discusses blocking action that began in the western Atlantic after mid-February 1951 and the associated effects on the movements of storms over the eastern half of the United States.

Blocking action<sup>1</sup> is characterized by the breakdown of essentially zonal motion into more cellular motion [3]. The importance of such a change lies not only in the altered flow pattern that results but also in the tendency for the cellular pattern to persist and remain quasi-stationary, often for as long as several weeks. In terms of fluctuations of the zonal index Rossby and Willett [5] describe four stages in the cycle of changes from one pattern to another. The first of these stages is that of initial high index characterized by, among other features, an expanding and strengthening jet stream located north of the normal seasonal latitude. The initial lowering of the high-index pattern occurs in the second stage after the jet stream has reached its maximum strength and moved near or south of the normal seasonal latitude. The low index pattern of the third stage brings about the development of strong troughs and ridges in the jet stream with cutting off of warm anticyclones in the higher latitudes and cold cyclones in the lower latitudes. The final stage is accompanied by the initial increase of the index pattern, the dissipation of the high-level cyclonic and anticyclonic cells, and the gradual re-establishment of the circumpolar vortex jet stream in the higher latitudes.

## DEVELOPMENT OF BLOCKING ACTION

The zonal index is a convenient tool for measuring large-scale changes in the circulation pattern. In figure 1, the fluctuation of the daily values of the zonal index at 700 mb. for the area 35°–55° N., 175° E.–5° W. serve as an indication of the stage of the cycle as described above.

<sup>1</sup> Rex [2] discusses the initiation, development, and dissipation of blocking in terms of a proposed physical mechanism which is analogous to a "jump" in hydraulic flow in open channels.

The initially high index prior to February 18 corresponds to stage one, the transitional falling period from February 18 to 22 is characteristic of stage two, while the period from February 23 to the end of the month (and well into the month of March) could be classified as stage three.

A more detailed picture of what occurred during the latter half of the month can be obtained from the 3-day mean profiles of zonal speed at 600 mb. for the area 135° W.–20° W., presented in figure 2. In the first curve the maximum at 50°–55° N. was somewhat stronger than normal and displaced far north of its normal seasonal position, a condition indicative of stage one. The pres-

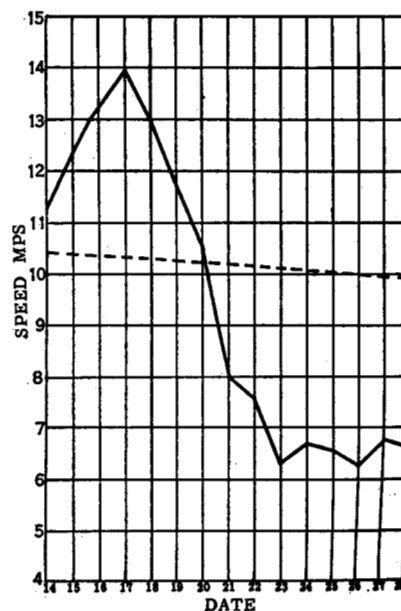


FIGURE 1.—Daily values of the 700-mb. zonal index in meters per second for area 35°–55° N., 175° E.–5° W. Dashed line represents February mean. (Data provided by Extended Forecast Section, Weather Bureau).

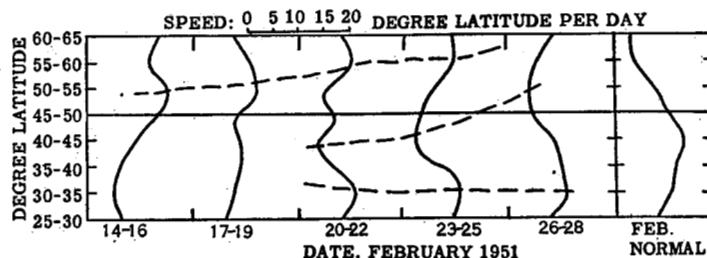


FIGURE 2.—Three-day mean profiles for 1500 GMT of zonal wind speed at 600 mb. for area 135° W.–20° W. Curve on right is mean for February. Dashed lines represent trends of maximum and minimum values. (Data provided by U. S. Air Force.)

ence of only one maximum and one minimum was normal for the season [5] but the pronounced minimum at  $30^{\circ}$ – $35^{\circ}$  N. represented a considerable deviation from the mean curve for February. Beginning with the curve of February 17–19 there was strong evidence that a change in circulation was evolving. On the days represented by that curve and thereafter there were generally present at least two maxima, as is especially evident from the curve of February 23–25. The two definite maxima that existed on those days, one at very low latitudes and the other at extremely high latitudes, were located at the same positions where minima existed approximately 10 days before. At the same time the minimum value was located precisely where a maximum is normally found. The migration of this minimum value<sup>2</sup> was associated with the northward migration of warm anticyclones. This effect of a split jet stream with the northern branch moving toward higher latitudes while the southern branch moves southward is one of the characteristics of blocking action [2].

In order to illustrate the splitting of the jet stream in more detail, with its resultant decrease in the zonal index, the 300-mb. charts of figures 3, 4, and 5 have been selected. In addition to the contours, isotachs (lines of equal wind speed) and the core of maximum speed have been indicated on these charts. The map of February 13 (fig. 3) shows that although the jet plunged far southward around a sharp trough in the western portion of the United States, over most of the continent the jet was located well north of normal seasonal latitudes. On February 17 (fig. 4) a completely changed pattern was observed. On that day two widely separated jets, which were undoubtedly reflected in the two maximum values of the zonal profiles,

<sup>2</sup> The occurrence of such migrations over long periods seems to be suggested by the work of Riehl et al. [6] who found long term trends in momentum changes in the westerlies. Momentum maxima and minima, according to this investigation, either progress steadily from the equator toward the pole or in the opposite direction.

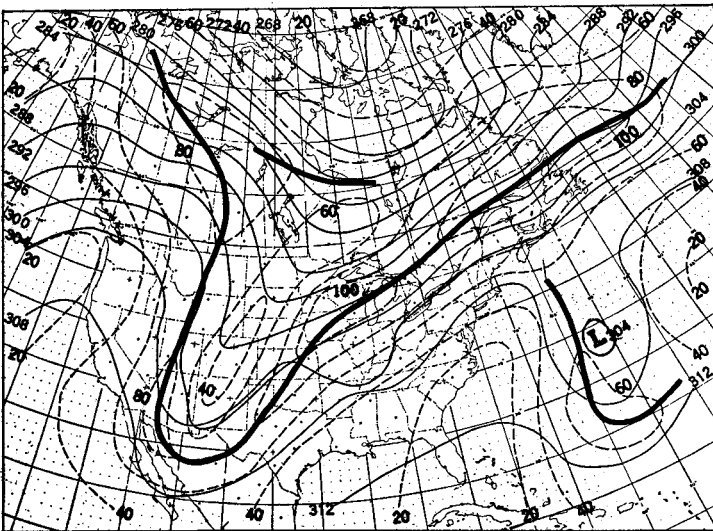


FIGURE 3.—300-mb. chart for 1500 GMT, February 13, 1951. Contours (solid lines) at 400-ft. intervals are labeled in hundreds of geopotential feet. Dashed lines represent isotachs (lines of equal speed) at intervals of 20 knots. Heavy line represents jet stream.

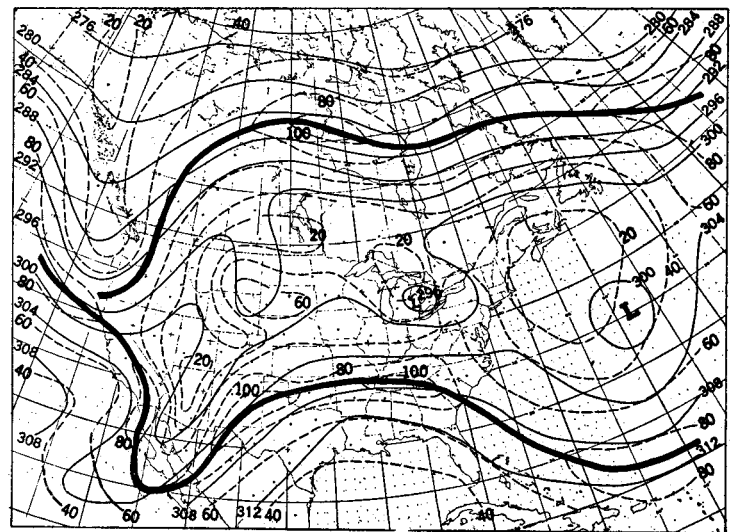


FIGURE 4.—300-mb. chart for 1500 GMT, February 17, 1951.

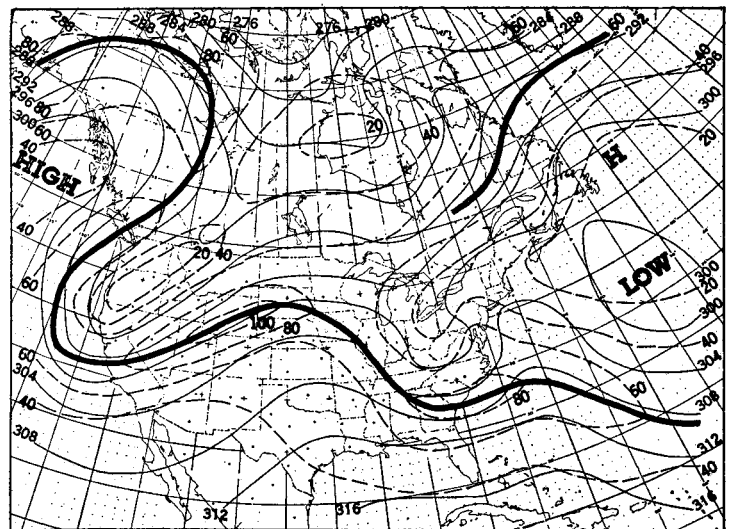


FIGURE 5.—300-mb. chart for 1500 GMT, February 21, 1951.

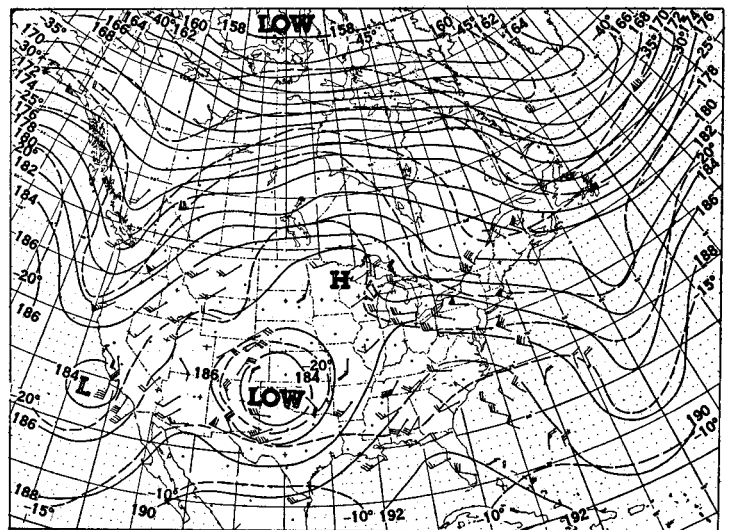


FIGURE 6.—500-mb. chart for 1500 GMT, February 15, 1951. Contours (solid lines) at 200-ft. intervals are labeled in hundreds of geopotential feet. Isotherms (dashed lines) are at intervals of  $5^{\circ}$  C. Barbs on wind shafts are for speeds in knots (pennant = 50 knots, full barb = 10 knots, and half barb = 5 knots).

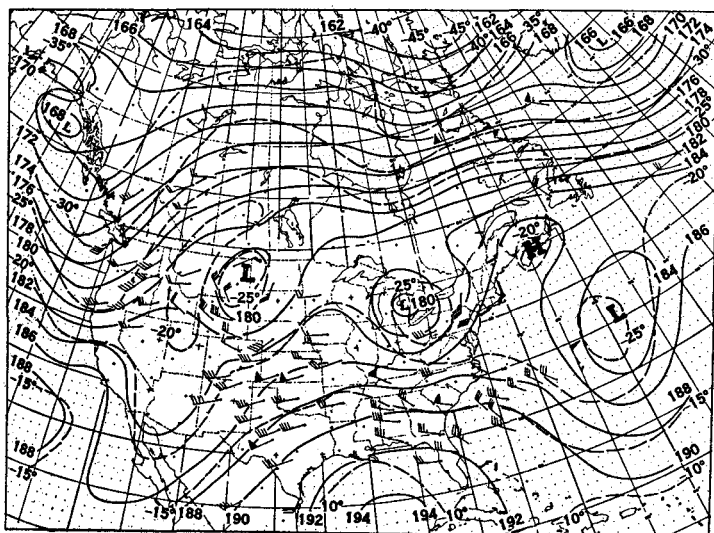


FIGURE 7.—500-mb. chart for 1500 GMT, February 17, 1951.

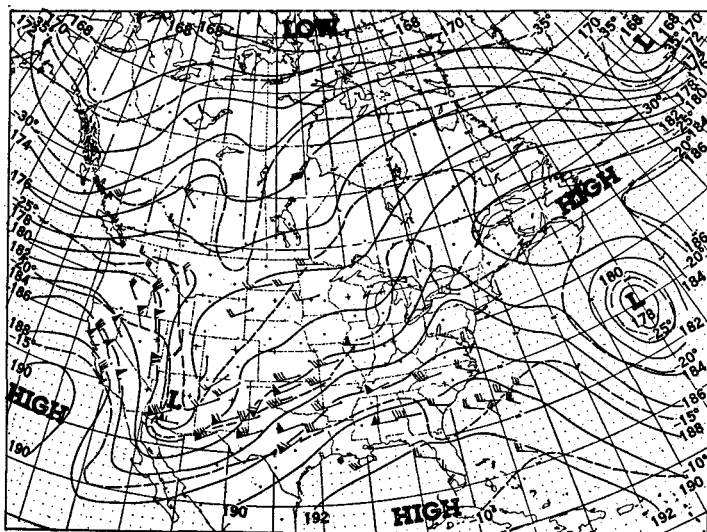


FIGURE 8.—500-mb. chart for 1500 GMT, February 19, 1951.

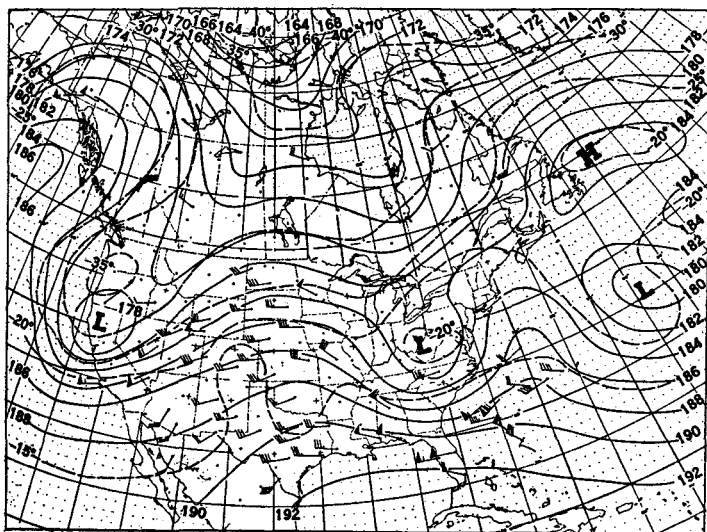


FIGURE 9.—500-mb. chart for 1500 GMT, February 21, 1951.

appeared over most of North America. By February 21 (fig. 5), the most northerly jet had weakened appreciably (also observed in fig. 2), although the southern branch persisted with little change. Concurrent with the wide breaching of the jet was the development of the ridge over Nova Scotia.

Another characteristic of blocking is its persistence. The continuous trends that can be seen in figures 1 and 2 illustrate this effect to some extent, although the period covered by the curves is relatively short.

#### THE QUASI-STATIONARY RIDGE ALONG THE NORTHEAST COAST

The anticyclone that became almost stationary over New England (fig. 12) originated as a polar outbreak from northwest Canada. Throughout the period under discussion its central pressure value slowly decreased. The warm anticyclone that existed at 500 mb. directly above the surface center on February 17 (figs. 7 and 13) had migrated from the west. After the surface and upper level positions coincided there was very little motion of the centers at any level. An illustration of the decreased temperature gradient that resulted along the east coast after the area became dominated by the extensive warm ridge and the zonal flow decreased, can be seen from a comparison of the upper-air soundings at the stationary ship "H" (36° N., 70° W.), Sable Island, Nova Scotia (44° N., 60° W.), and Stephenville, Newfoundland (48° N., 58° W.) taken on February 15 and 19 (figs. 10 and 11). Of interest also is the cooling that occurred in the upper levels of the troposphere and the stratosphere at these three stations, particularly marked at Stephenville.

The first indication at the 500-mb. level (figs. 6 to 9) that a change in regime was evolving was the appearance of a cold, "cutoff" Low on February 14 centered over the Texas Panhandle. After February 14 the flow pattern over North America rapidly changed to one of low index although the zonal index value for half the hemisphere (fig. 1) remained high until February 17. By February 17 (fig. 7), another cold Low developed over the Atlantic Ocean to the northeast of Bermuda and persisted in approximately the same position for 5 days. Northwest of this Low, a well-developed ridge just off the coast had decelerated markedly and had become almost stationary. New "cutoff" Lows continued to develop over the mid-western portion of the United States and move eastward or northeastward. Each had a similar history of initial deepening and subsequent filling as it neared the ridge line along the east coast. It was not until February 24, that a Low at 500 mb. which formed in Virginia finally penetrated the coast line and moved eastward into the Atlantic Ocean. However, it stagnated within 150 miles of the coast and finally proceeded slowly northeastward, dissipating over Newfoundland on February 27.

The ridge along the east coast did move eastward after February 21 but that did not signify the end of blocking

action affecting the North American continent. The blocking action merely appeared to be displaced upstream. Following this period a well-developed ridge dominated the eastern half of the United States for several days and, near the end of the month, another great ridge formed along the Pacific coast of the continent.

### EFFECT OF BLOCKING ACTION ON SURFACE CYCLONES

The normal track of cyclones that form or move into the eastern United States or the western Atlantic is toward the northeast [7]. They also tend to deepen as they move toward higher latitudes. During the period of blocking action, however, the storms that appeared deviated considerably from normal.

One case of great deviation in the behavior of cyclones

was that of the Low that formed east of Bermuda on February 13 and remained quasi-stationary in the area for many days. There were also cases of Lows directly affecting the United States. The Low that formed in Louisiana as the ridge was becoming established along the East coast (figs. 12 and 13) moved almost directly north, with even a slight westerly component. That Low had initially shown signs of deepening at the surface but by the time it reached the State of Iowa at 1830 GMT on February 16 it began to fill rapidly. The cold High cell behind the front gradually merged with the ridge off the coast. The rapid occlusion of the wave gives some indication of the tenacity of the ridge along the coast.

A second storm, which formed in the Texas Panhandle, moved slowly northeastward and filled much in the same manner as the first. A remnant of this Low was located near Ottawa, Ontario, on February 20 (fig. 14).

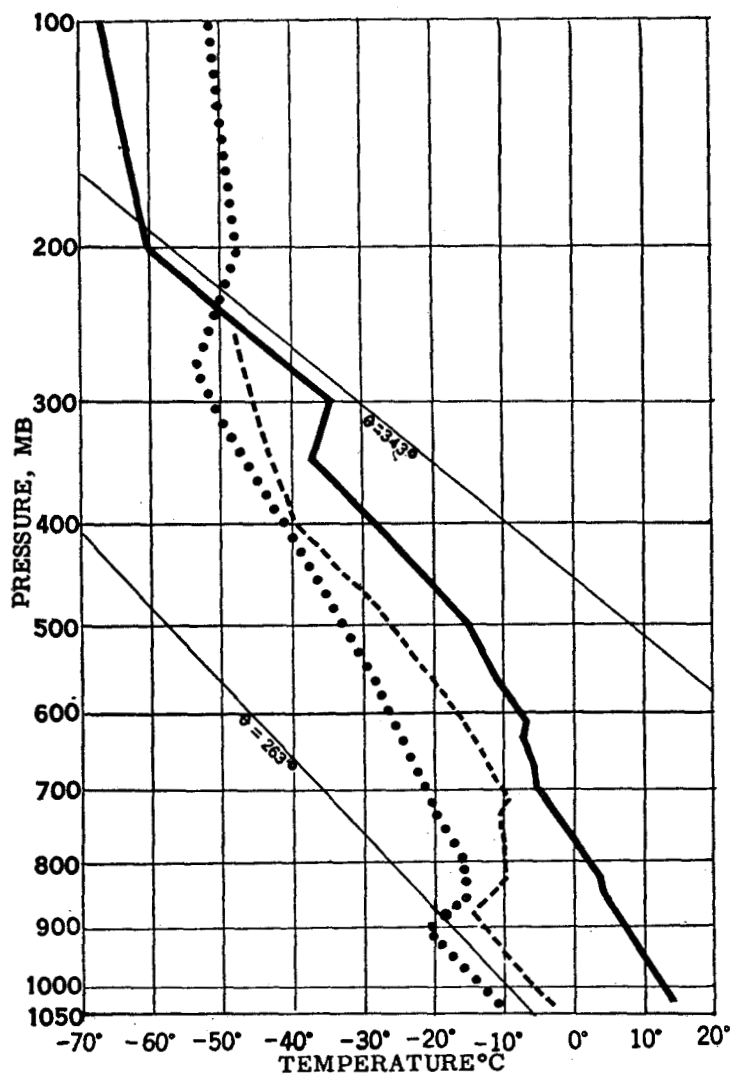


FIGURE 10.—Radiosonde observations at ship "H" 36.0° N., 70.0° W. (solid line), Sable Island, Nova Scotia (dashed line), and Stephenville, Newfoundland (dotted line), for 1500 GMT, February 15, 1951.

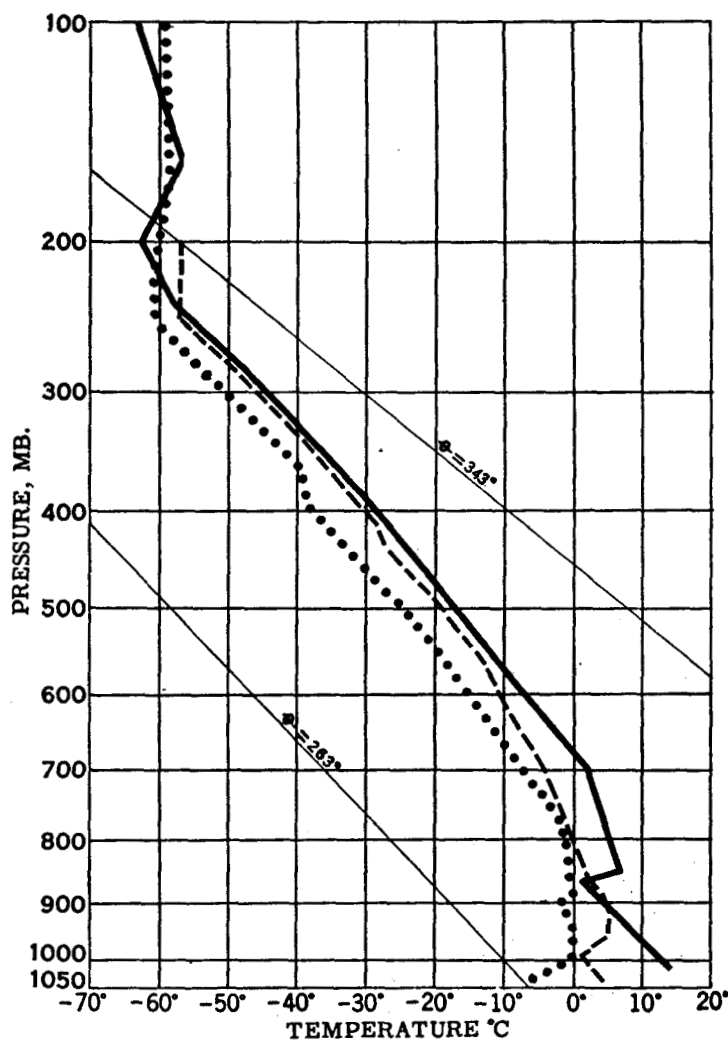


FIGURE 11.—Radiosonde observations at ship "H" 36.0° N., 70.0° W. (solid line), Sable Island, Nova Scotia (dashed line), and Stephenville, Newfoundland (dotted line), for 1500 GMT, February 19, 1951.

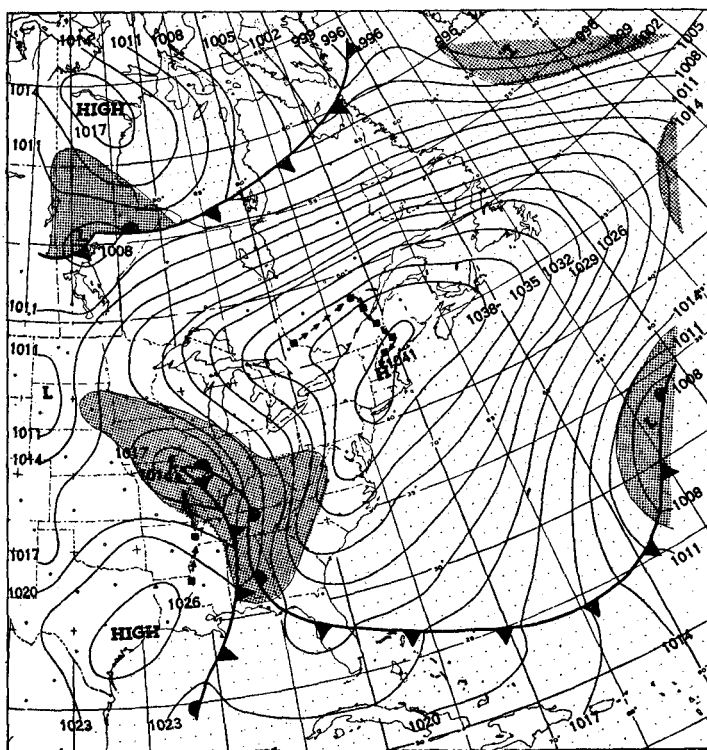


FIGURE 12.—Surface weather chart for 1230 GMT, February 16, 1951. Shading indicates areas of active precipitation.

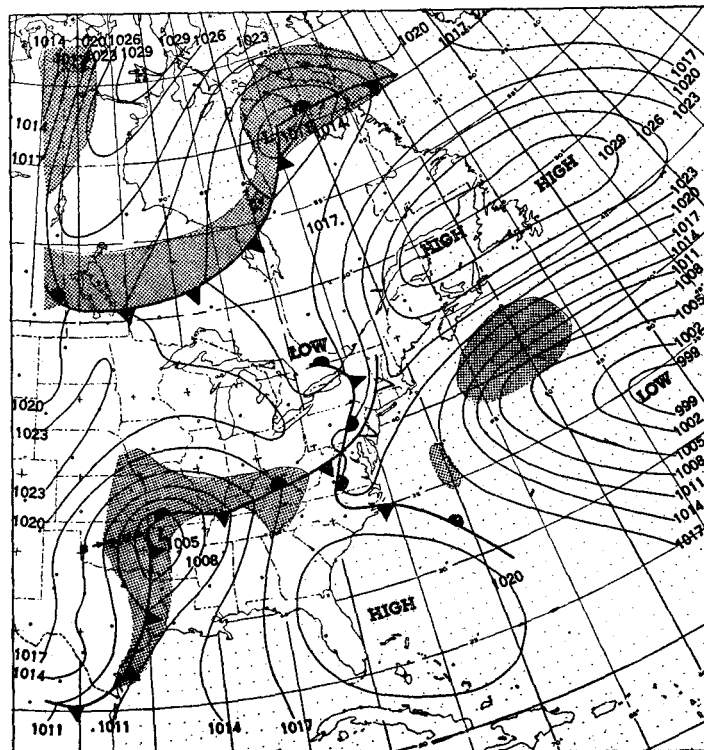


FIGURE 14.—Surface weather chart for 1230 GMT, February 20, 1951.

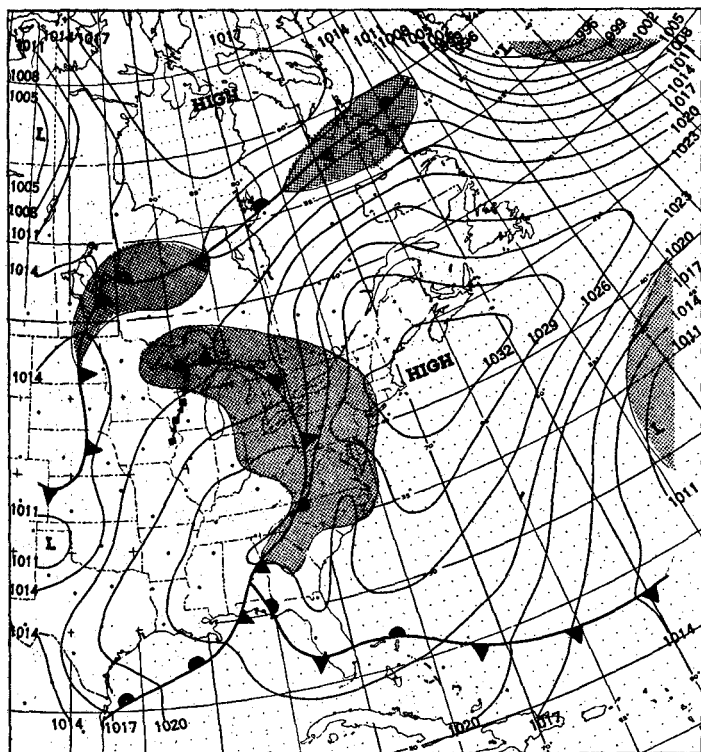


FIGURE 13.—Surface weather chart for 1230 GMT, February 17, 1951.

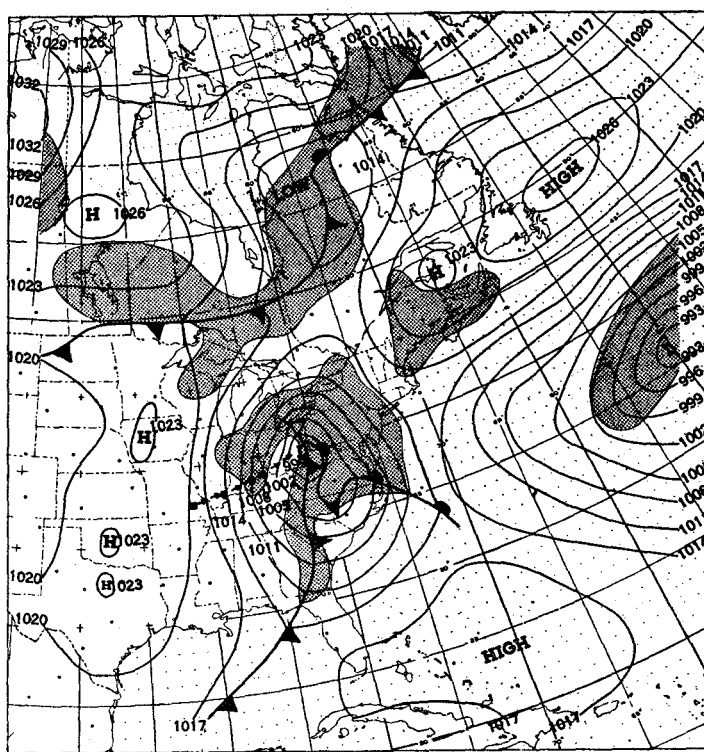


FIGURE 15.—Surface weather chart for 1230 GMT, February 21, 1951.



